Electrostatics of Airborne Granular Material

Airborne granular material in the size range from about 1 micrometer up to one millimeter can acquire comparatively large electrostatic charges due to multiple contacts between particles and to particle collisions with different surfaces. Highly charged particulate matter of this size can be attracted to surfaces. Dust control in clean environments can become difficult due to these charged particles. On the other hand, charged granular material has many beneficial applications. Devices such as electrostatic copiers, inkjet printers, powder coating machines, injection moldings, and electrostatic precipitators, depend on controlled charging of these small particles. The Electromagnetic Physics Laboratory at KSC is engaged in studies leading to a better understanding of the electrostatics of granular material.

Surfaces can become charged due to contact and separation between materials of different Fermi electronic energy levels. In a vacuum, these excess charges can remain on surfaces indefinitely. In a gaseous atmosphere, excess charge can leak away due to the presence of free charges in the gas such as ions, electrons, or other heavily charged particles. At low atmospheric pressures, the number of free space charges is reduced, affecting the discharging characteristics of surfaces in specific ways.

To study charge exchange phenomenon in granular material, a KSC-designed low pressure dust impeller together with an aerodynamic multisensor electrometer are used. Small particles ranging in size from about 5 to 17 micrometers are launched toward several cylindrical polymers in a dry carbon dioxide atmosphere at 9 mbars. Electrostatic sensors embedded in the aerodynamic multisensor measure the electrostatic charge generated on these polymers in real time. Figure 1 shows a simulation of particle flow around the aerodynamic multisensor. In an initial attempt at characterizing this interaction, a *triboelectric series* was generated. In this series, the materials are ordered according to the relative positions of their electronic energy levels when brought into contact.

Figures 2-4 show the electrometer responses to the charge exchanged between Fiberglass, Lucite, and Teflon? when in contact with silicon dioxide, aluminum oxide, and iron oxide particles. Table 1 lists the ordering of the minerals and the polymers in a triboelectric series, based on the data shown in Figs. 2-4. The average electrostatic responses of the polymers to the granular minerals may allow us to observe consistent differences in behavior, which could lead to a possible identification of such minerals.

Table 1. Triboelectric Series

Polymer	Granular Mineral
Most Positive	
	Fe_2O_3
Fiberglass	
Lucite	
	CaO
	Al_2O_3
	SiO_2
Teflon	
Most Negative	

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FIGURE 1

Figure 1. Computer simulation of particle flow around the cylindrical multisensor electrometer.

FIGURE 2

Figure 1. Electrometer responses to SiO_2 particles striking Fiberglass, Lucite and Teflon cylinders.

FIGURE 3

Figure 2. Electrometer responses to Al_2O_3 particles striking Fiberglass, Lucite and Teflon cylinders.

FIGURE 4

Figure 3. Electrometer responses to Fe_2O_3 particles striking Fiberglass, Lucite and Teflon cylinders.